discharge circuit

for 1.2 V sintered NiCd batteries

Developments in the world of rechargeable batteries, and the new models that have appeared in recent years, such as the metal hydride battery and the lithium-ion battery, are mainly of interest in the electronics industry. Many experimenters, hobbyists and other amateurs have stuck to NiCd cells and batteries, which have now been with us since the 1950s. The main reason for this popularity is probably their user-friendly behaviour (which is exceeded only by sealed lead-acid batteries). Another factor in favour of the NiCd battery is its low internal resistance (at least as far as sintered types are concerned), which enables it to provide fairly large currents (but not as high as lead-acid batteries).

Design by K Walraven

The nickel-cadmium battery is mechanically rugged and long-lived. It has excellent low-temperature characteristics and can be hermetically sealed. Cost, however, is higher than for the lead-acid or nickel-zinc battery. In many applications, the use of a sealed lead-acid battery is to be preferred over the other two types.

A slight drawback of a sintered NiCd battery is its so-called memory effect, which is fortunately completely reversible. It should be noted that mass plate nickel-cadmium cells and batteries do not develop the memory effect in any circumstances. The present circuit is, therefore, primarily intended for use with sintered NiCd 1.2 V cells.

LOW INTERNAL RESISTANCE

The ability of NiCd batteries to provide fairly large currents (because of their low internal resistance – at least as far as sintered types are concerned) is an important factor for the amateur fraternity, since many home-made model units draw fairly large currents. As a comparison, the d.c. resistance of three types of fully charged 1 Ah, 1.2 V sealed cell is

Standard	110 mΩ/cell
Heavy duty	50 mΩ/cell
Sintered	19 mΩ/cell

ENVIRONMENTAL EFFECTS

One of the most serious drawbacks of NiCd batteries is their effect on the environment. This type of battery contains cadmium which is toxic. In most countries, discarded NiCd batteries are dumped on the rubbish heap where they remain toxic for a very long time. It is true, of course, that their life of some 500–800 charge/discharge cycles does not cause millions of them to be disposed of on the rubbish heap. Nevertheless, this was a very important factor in the decision of manufacturers in general to discontinue the use of NiCd batteries in most consumer products.

MEMORY EFFECT

Another disadvantage of sintered (not mass plate) NiCd batteries is, as already mentioned, their memory effect. This manifests itself in the cell retaining the characteristics of previous cycling. That is, after repeated shallow-depth discharges the cell will fail to provide a satisfactory full-depth discharge. Note, however, that Eveready cylindrical nickel-cadmium cells are particularly noted for their lack of memory effect.

The memory effect is a nuisance, because it means that a battery with a nominal capacity of, say, 600 mAh, after a number of charge/discharge cycles has a useful capacity of only 300 or 400 mAh. This has nothing to do with the life of the battery: even a new battery if charged as stated will soon lose part of its capacity.

Fortunately, this reduction in capacity can be prevented fairly simply. Moreover, batteries that already suffer from the memory effect can be restored to their nominal capacity. The cure is simply to ensure that a battery is occasionally fully discharged before it is recharged. Occasionally means before every third or so recharge. Note that there are chargers on the market that have the discharge facility built in, but this will certainly not be the case in the less expensive types.

CORRECT DISCHARGING

There is no need for extensive circuitry to discharge a battery: a simple resistor or light bulb will accomplish it readily. It is, however, necessary to keep an eye on the discharge time, because otherwise there is the risk that the battery is discharged beyond a certain voltage. When this happens, it may cause polarity reversal in the cells comprising the battery.

Correct discharging can only take place via a circuit that arranges for the battery to be discharged to a certain level and then disconnects it from the discharge circuit.

The diagram of such a circuit – see **Figure 1** – is pretty straightforward. Nevertheless, such a discharge circuit does the job correctly. It causes a battery to be discharged to a level of 650 mV. This level ensures that the battery is correctly discharged without the risk of polarity reversal. The battery is not discharged at a constant current, but in short bursts. This allows the battery to 'recover' during the intervals, which, in practice, has been found to extend its useful life.

During the discharge, an LED lights to show that the process is continuing. Since the diode cannot work from a voltage of 0.65–1.2 V, the voltage has to be raised. To this end, the astable multivibrator formed by T_1 and T_2 oscillates at a rate of 25 kHz. When T_2 is on, current flows through inductor L_1, so that energy is stored in the magnetic field. When T_2 is off, the inductor is 'discharged' via the LED, whereupon this lights.

Diode D_1 prevents the energy stored in the inductor from leaking away via the base of T_1. This might happen because the capacitors in the circuit have fairly high values, whereas the resistors have low ones. The chosen values ensure that the discharge current is sufficiently high. When the battery voltage is 1.2 V, the discharge current is some 200 mA; at 0.8 V, it has dropped to about 100 mA, and at 0.65 V to around 50 mA. When the battery voltage drops to 0.65 V, the discharge process is discontinued.

CONSTRUCTION

The tiny circuit is best built on the printed-circuit board shown in **Figure 2**, but this is not available ready made. However, a small prototyping board will do very nicely as well.

Inductor L_1 is a small choke which should be readily available from most electronics retailers.

The LED should be a high-efficiency type, while, because of the threshold discharge voltage, D_1 must be a Schottky type.

USAGE

There is not much that can be said about using the discharge unit. It is simply a matter of connecting the 1.2 V battery with correct polarity, checking that the LED lights, and disconnecting the battery when the LED goes (or is) out.

In general, the discharge period will normally be three to four hours. As mentioned before, the battery does not need to be discharged fully before it is recharged: before every third recharge will be fine.

If a battery is suspected of suffering from the memory effect, discharge and recharge it two or three times in succession. This action will in almost all cases restore the capacity of the battery completely (commensurate with its life, of course).

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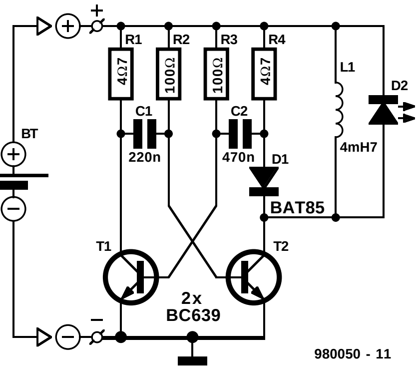

Figure 1. The circuit is basically an astable multivibrator oscillating at a rate of 25 kHz.

2

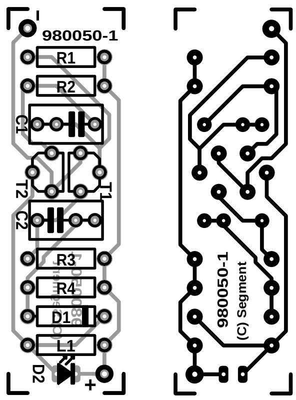

Figure 2. The discharge circuit is intended for 1.2 V batteries. If several of these, or a 9 V rechargeable NiCd battery, have to be discharged, an appropriate number of PCBs are needed.

Parts list

Resistors:
R_1, R_4 = 4.7 Ω
R_2, R_3 = 100 Ω

Capacitors:
C_1 = 0.22 μF
C_2 = 0.47 μF

Inductors:
L_1 = choke, 4.7 mH

Semiconductors:
D_1 = BAT85
D_2 = LED, red, high efficiency
T_1, T_2 = BC63